

Summary of Field Quality Data in D3L103

Animesh Jain

Superconducting Magnet Division

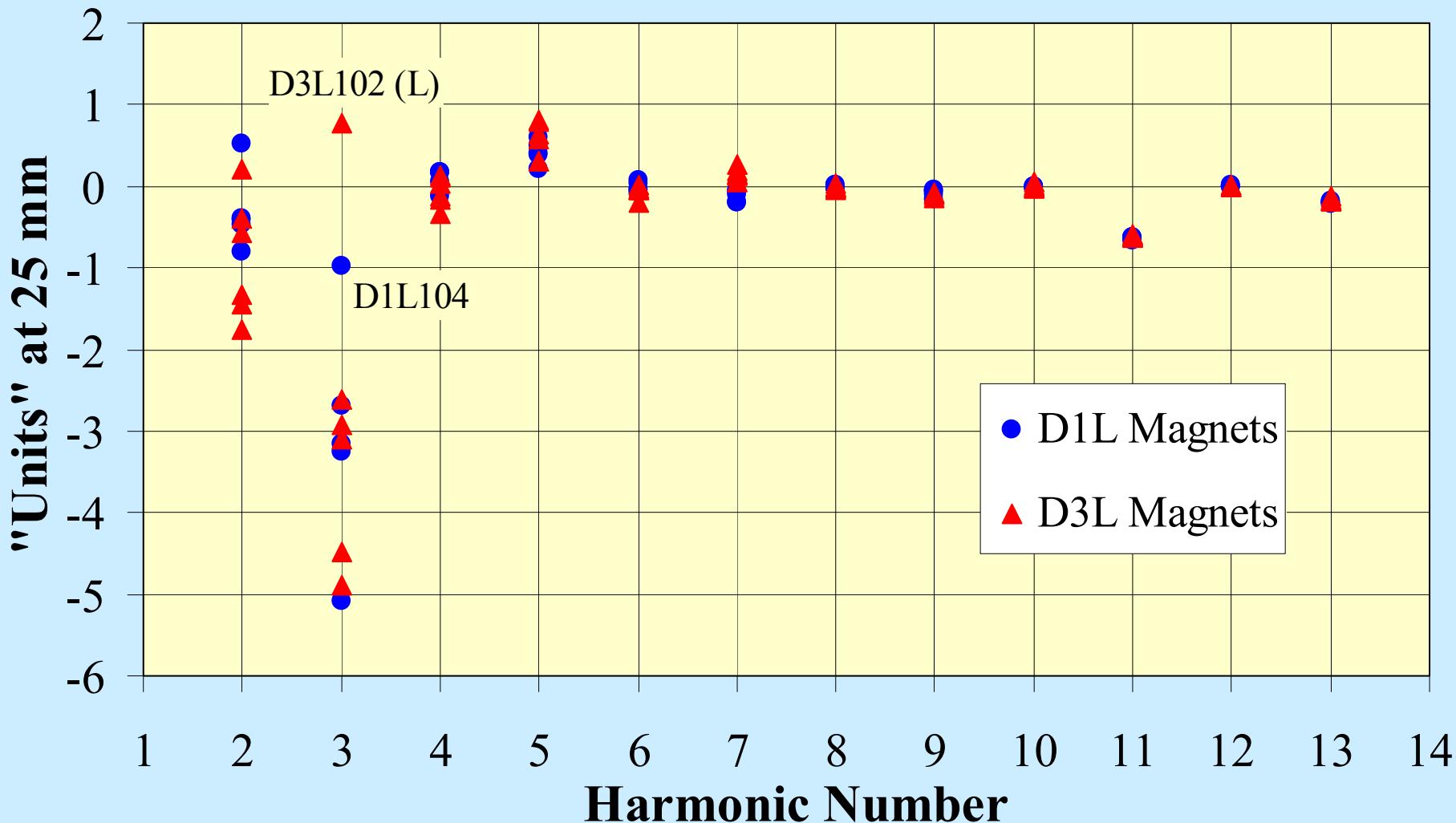
Brookhaven National Laboratory, Upton, NY 11973

D3L103 Field Quality Acceptance, BNL, December 13, 2005

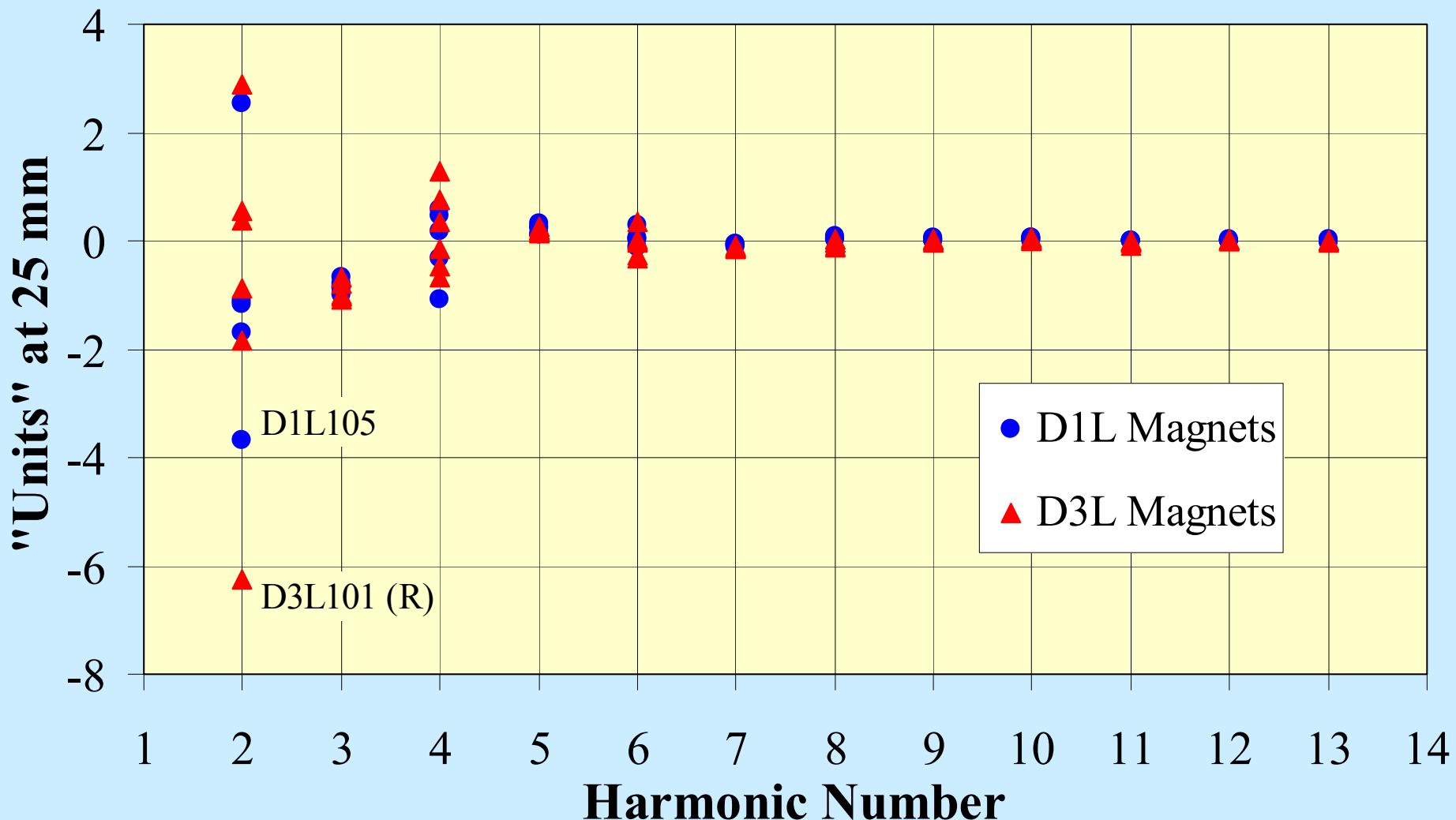
Warm Measurements

- Warm measurements have been completed in all the three D3 dipoles, using a 1 meter long mole at 10 axial locations in each aperture.
- Field angle is measured relative to gravity. Systematic error in calibration is removed by measuring field angles from both ends.
- Fiducials are surveyed on the test stand. Survey and field angle data are combined as per agreement with CERN regarding coordinate transformations.
- Integral transfer function is measured with a non-rotating, 10-meter long coil.
- All warm measurements are done *before* cold test.
(All the D1's were measured *after* cold test— T.F. diff.)
- The *warm harmonics* in D3 are consistent with the D1 dipoles. (The cold harmonics differ due to cross-talk.)

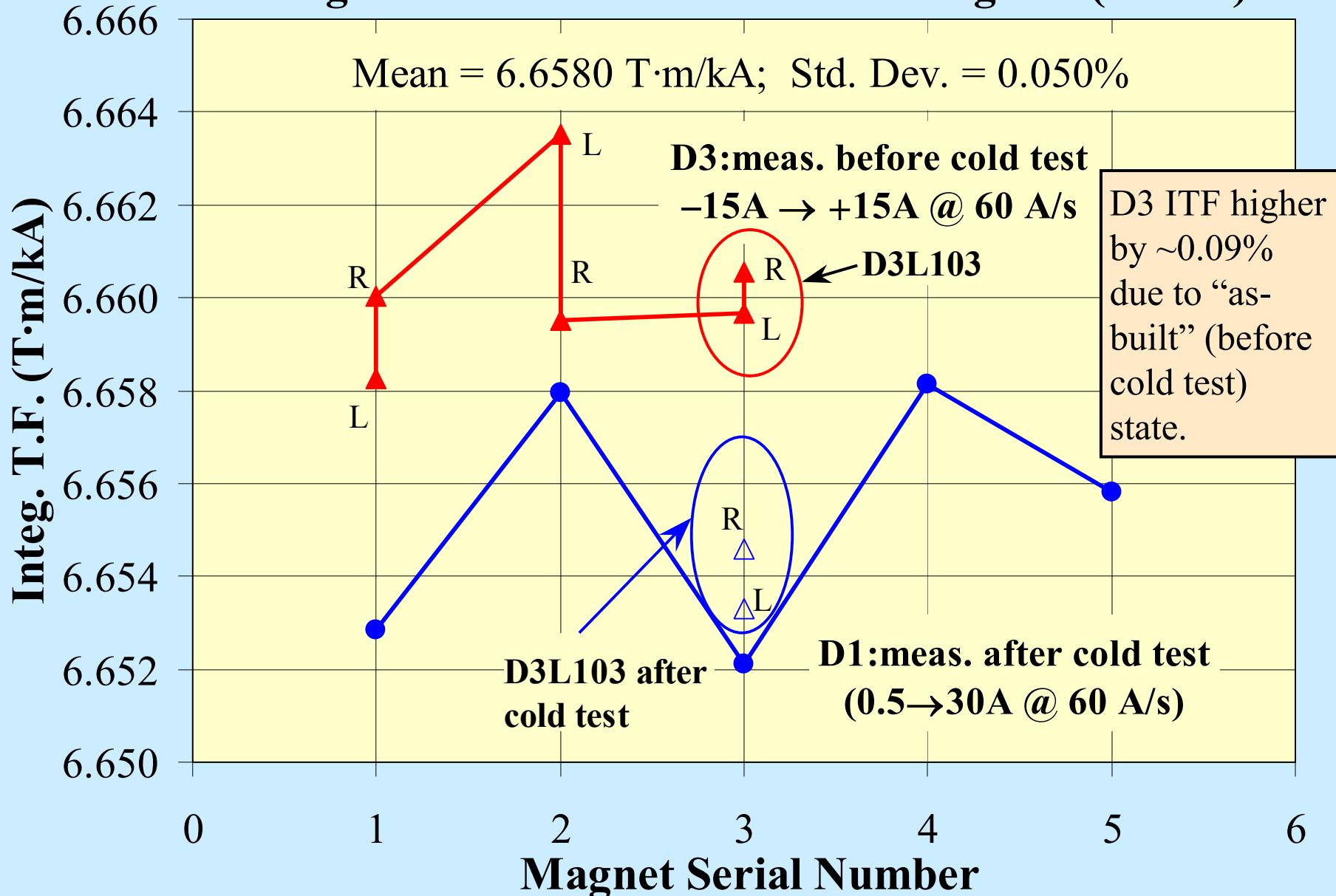
Int. Normal Harmonics in D1/D3 Magnets (Warm)



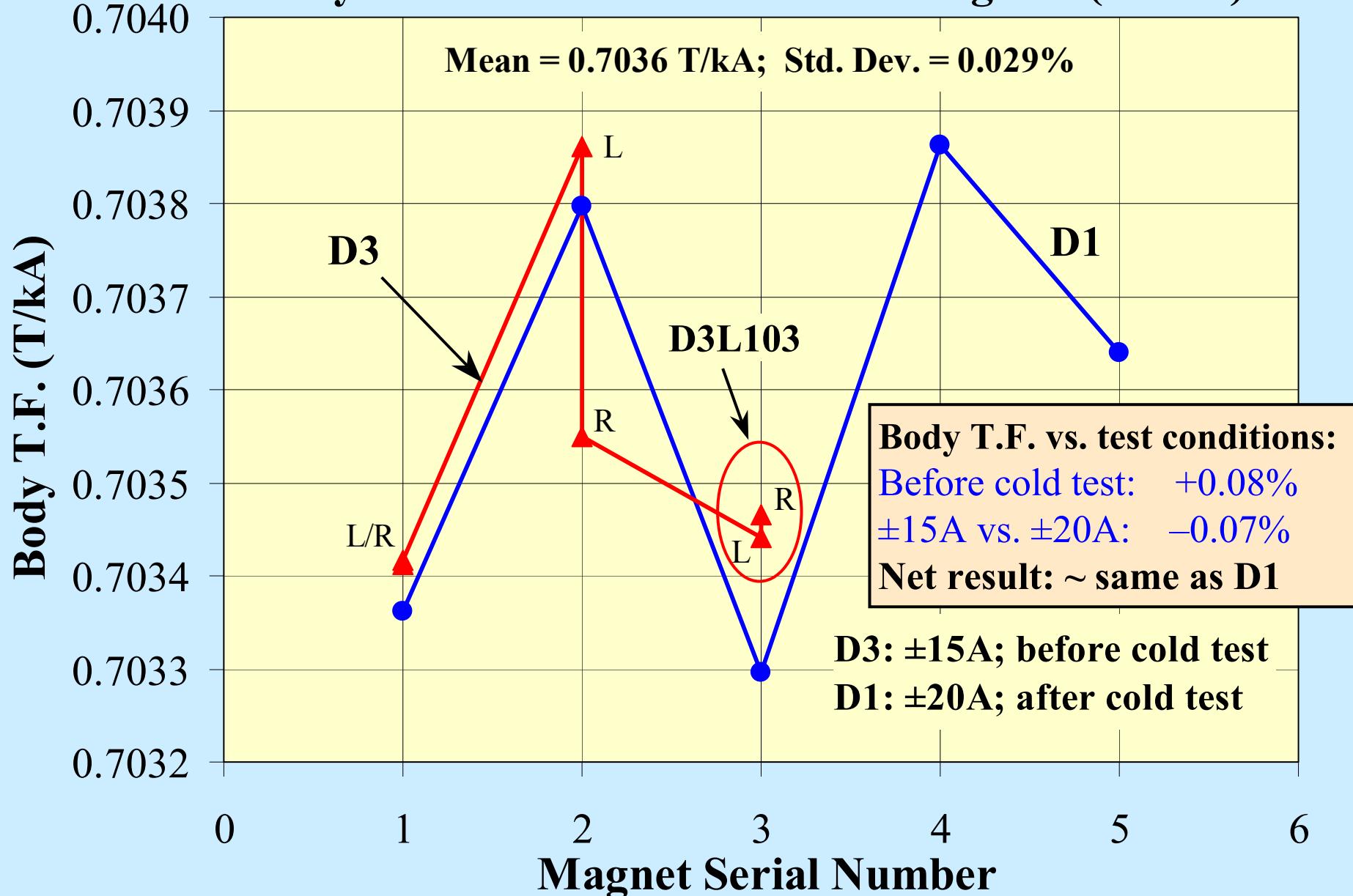
Int. Skew Harmonics in D1/D3 Magnets (Warm)



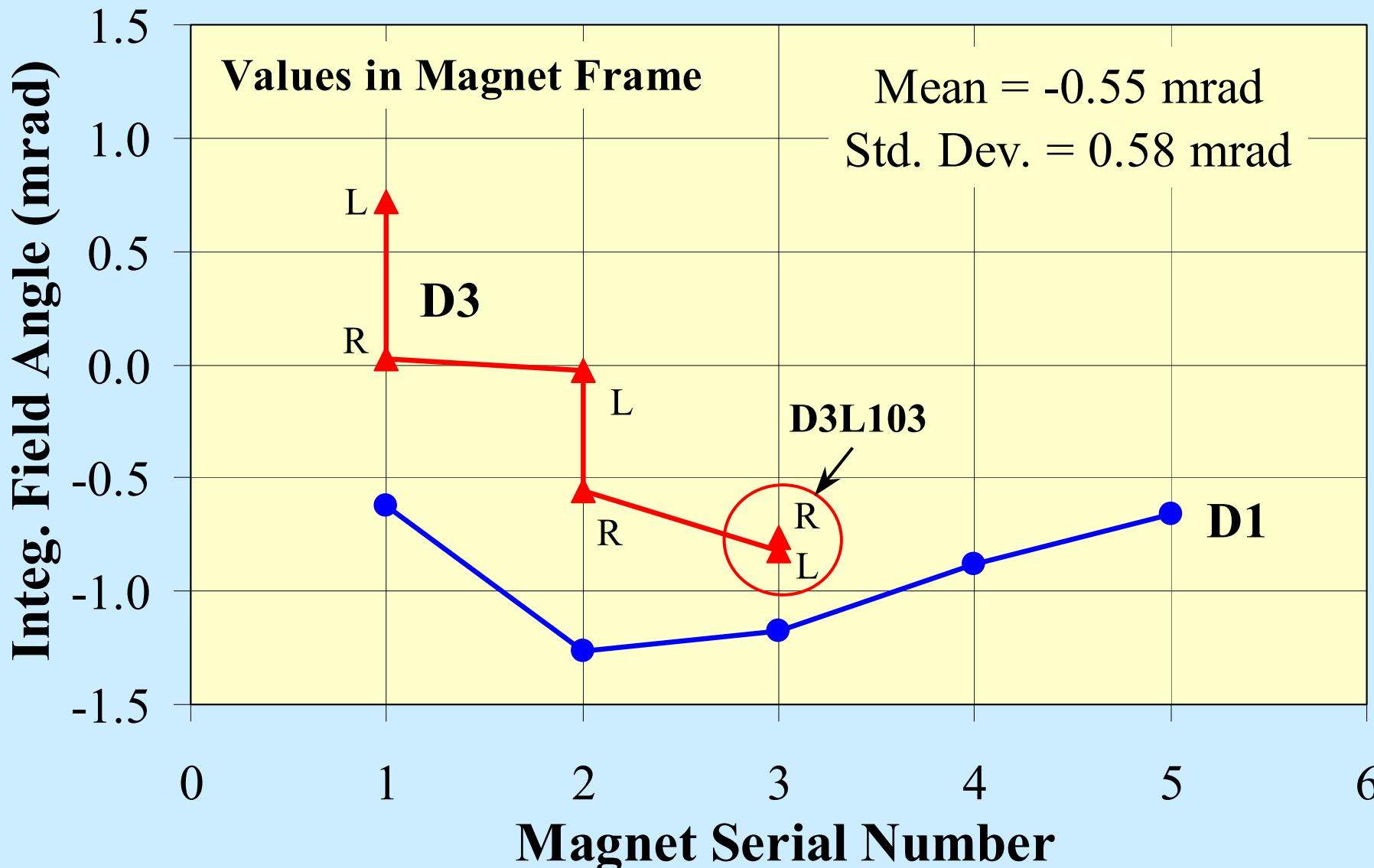
Integral Trans. Func. in D1/D3L Magnets (Warm)



Body Transfer Func. in D1/D3L Magnets (Warm)



Integ. Field Angle in D1/D3 Magnets (Warm)



D3L103 Vs. Mean and Standard Deviation

Integral Normal Harmonics (Warm) in units at 25 mm



	D1L/D3L Mean	D1L/D3L Std.Dev.	D3L103(L)	No. of Sigma	D3L103(R)	No. of Sigma
I.T.F. (T.m/kA)	6.6548	0.034%	6.6537	-0.5	6.6546	-0.1
Quadrupole	-0.62	0.68	-1.75	-1.7	-0.40	0.3
Sextupole	-2.94	1.70	-4.88	-1.1	-2.92	0.0
Octupole	0.01	0.17	-0.34	-2.1	0.03	0.1
Decapole	0.50	0.20	0.31	-1.0	0.80	1.5
12-pole	-0.04	0.07	-0.20	-2.4	-0.04	-0.1
14-pole	0.03	0.16	0.19	1.0	0.27	1.5
16-pole	-0.01	0.02	0.03	2.1	-0.03	-0.8
18-pole	-0.10	0.03	-0.09	0.2	-0.11	-0.3
20-pole	0.00	0.02	0.06	2.6	-0.02	-1.0
22-pole	-0.62	0.02	-0.59	1.6	-0.63	-0.1
24-pole	0.00	0.01	0.02	2.6	0.00	-0.7
26-pole	-0.18	0.03	-0.12	2.2	-0.18	0.2

Note: ITF in all the D3's is divided by 1.0009 to match D1 measurements

D3L103 Vs. Mean and Standard Deviation

Integral Skew Harmonics (Warm) in units at 25 mm

	D1L/D3L Mean	D1L/D3L Std.Dev.	D3L103(L)	No. of Sigma	D3L103(R)	No. of Sigma
Field Angle (mrad)	-0.55	0.58	-0.83	-0.5	-0.76	-0.4
Quadrupole	-0.93	2.61	-0.88	0.0	-1.84	-0.3
Sextupole	-0.89	0.14	-1.00	-0.7	-1.08	-1.3
Octupole	0.08	0.69	-0.47	-0.8	-0.15	-0.3
Decapole	0.20	0.07	0.19	-0.1	0.20	0.1
12-pole	0.01	0.20	-0.26	-1.3	0.03	0.1
14-pole	-0.11	0.03	-0.14	-1.2	-0.11	-0.2
16-pole	0.00	0.06	-0.11	-1.8	0.04	0.6
18-pole	0.01	0.02	-0.03	-1.8	0.03	0.8
20-pole	0.03	0.02	-0.01	-1.7	0.05	0.7
22-pole	-0.01	0.02	-0.08	-2.8	0.00	0.5
24-pole	0.00	0.01	0.00	-0.9	0.02	1.9
26-pole	0.00	0.01	-0.02	-1.9	0.01	0.7

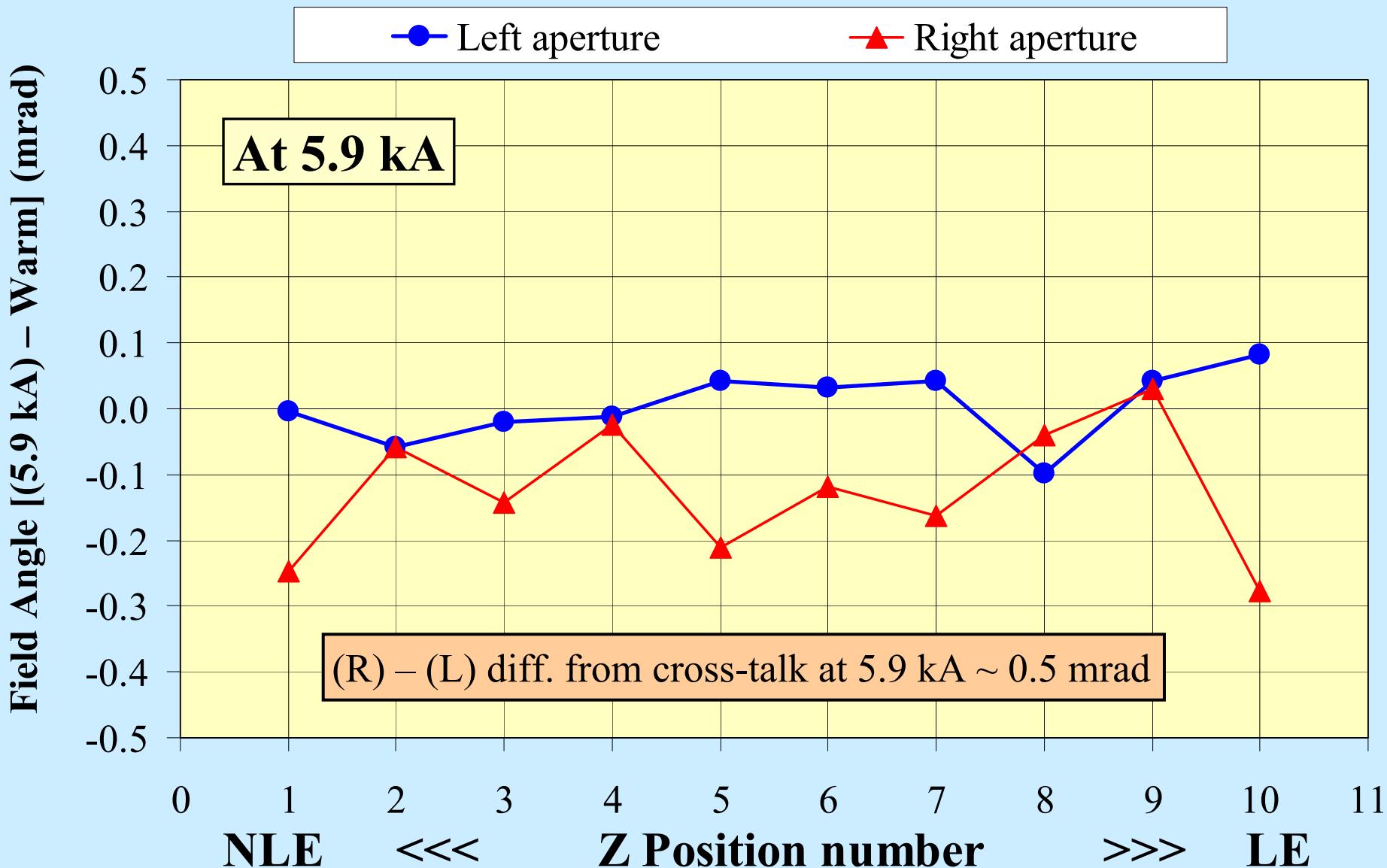
Cold Measurements

- Sparse excitation curves (19 currents) were measured at each of the 10 axial positions, in each aperture.
- The 19 currents in the sparse loop cover 200A (0.14 T) to 5900A (3.9 T).
- The integral T.F. is obtained from Z-scan only, and can have errors of up to ~0.1%.
- D3L103(Left) ITF was adjusted based on warm-cold.
- Down ramp measurements are done at only one position in each aperture.
- No dynamic measurements were made in D3L103.

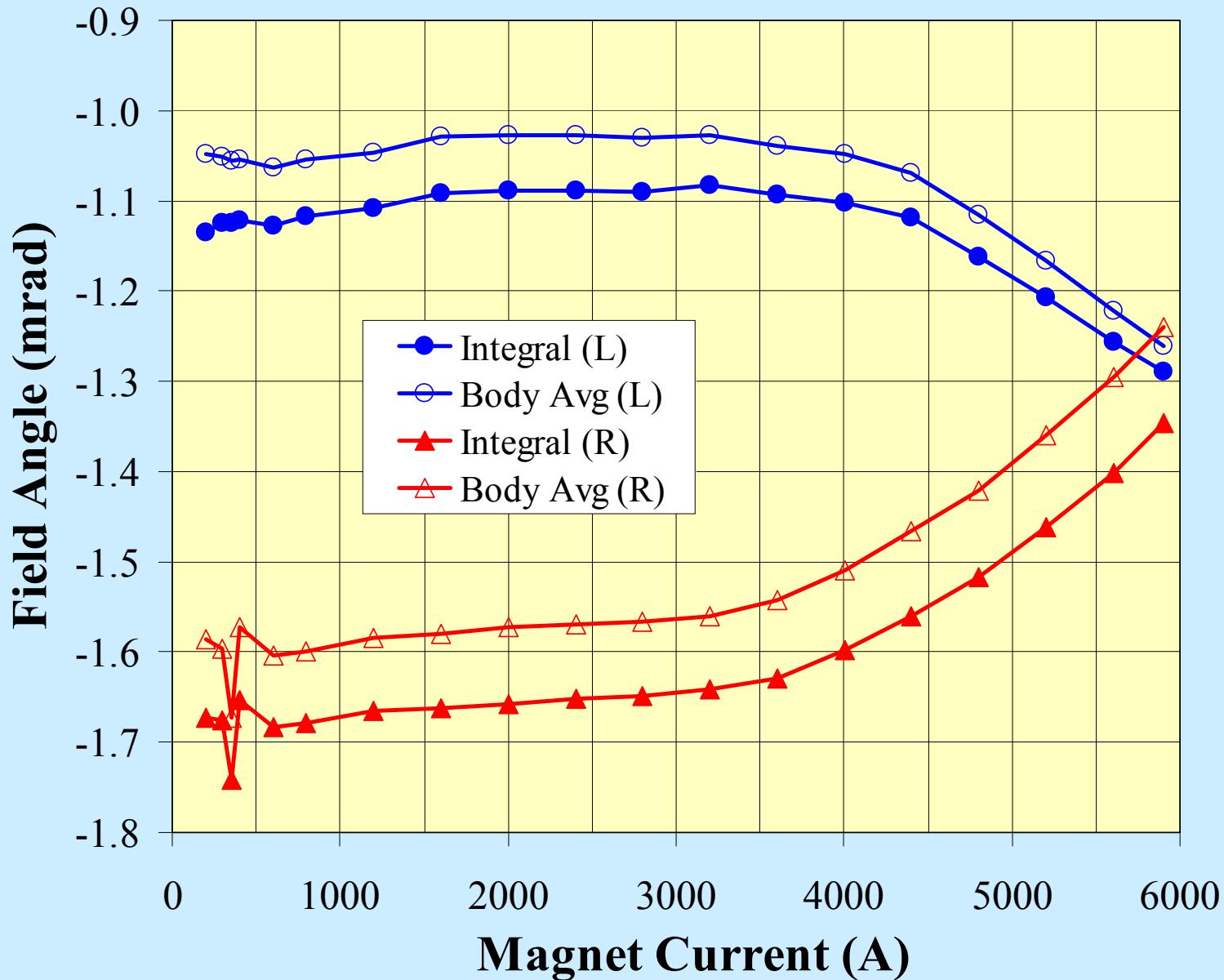
Field Angle Changes on Cool Down in D3L103



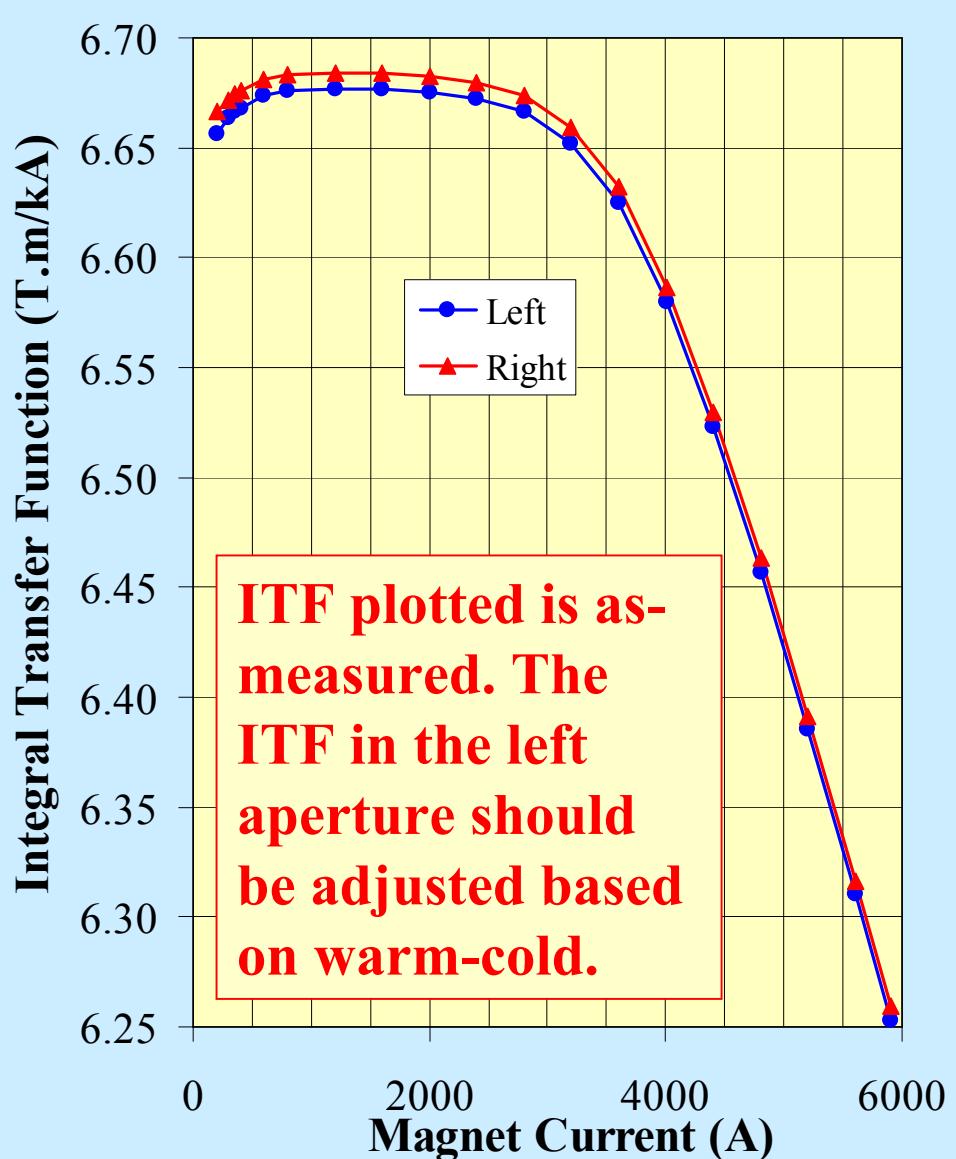
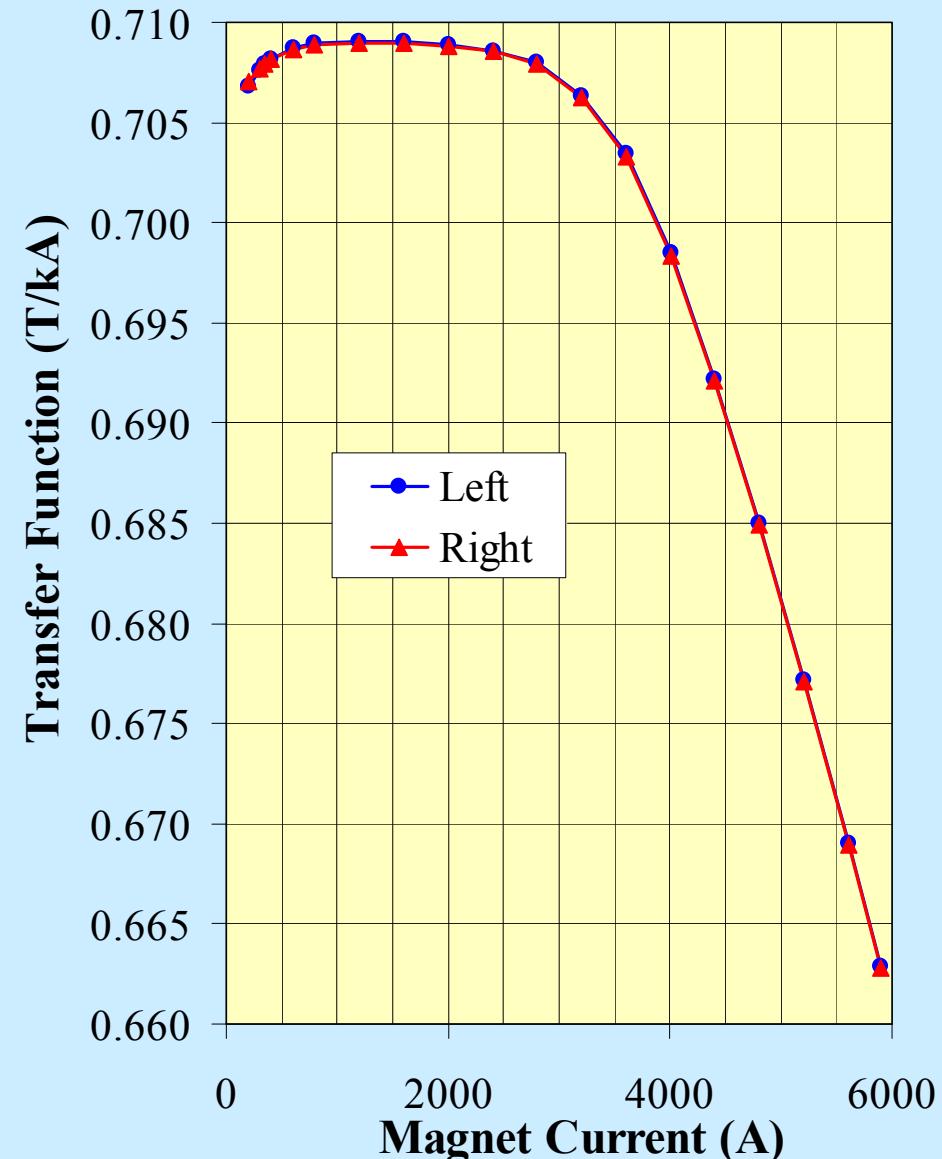
Field Angle Changes on Cool Down in D3L103



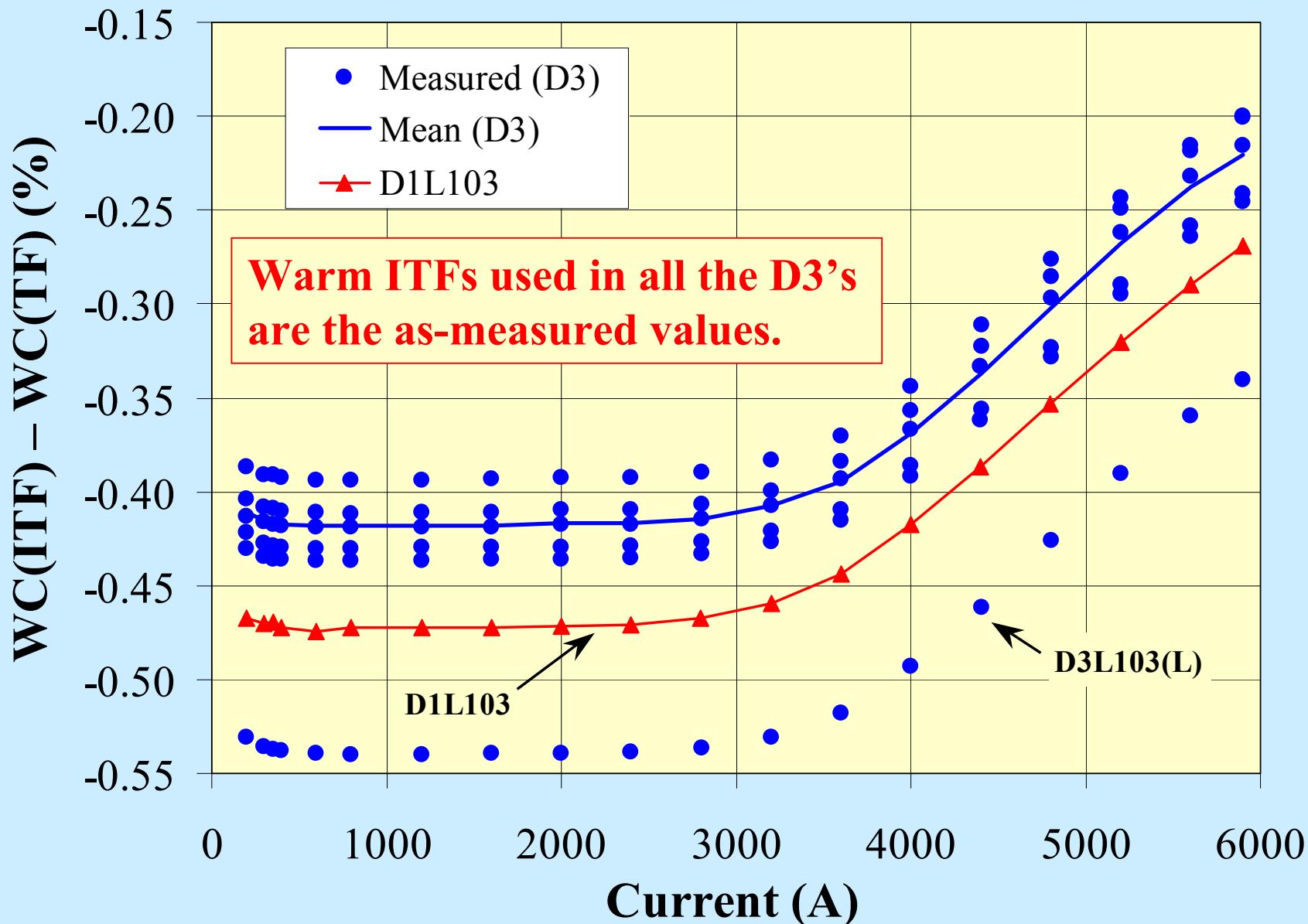
St. Section and Integral Field Angles in D3L103



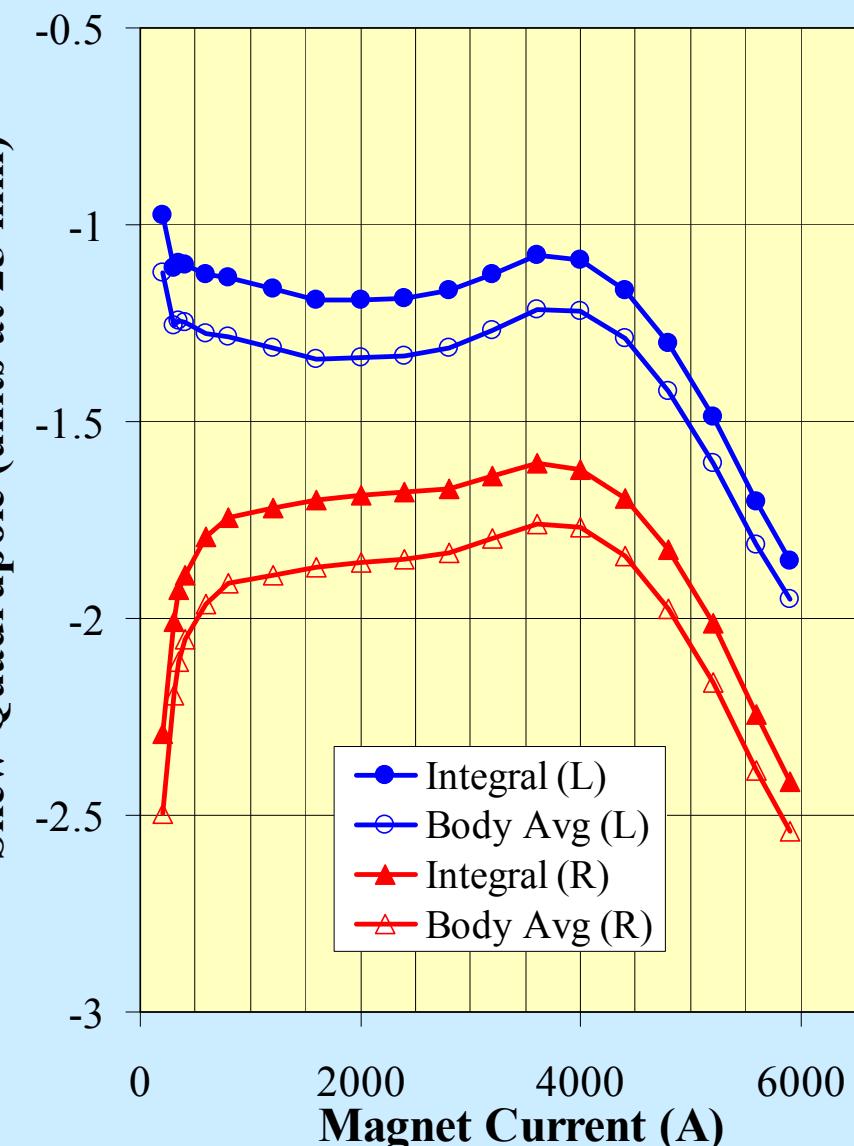
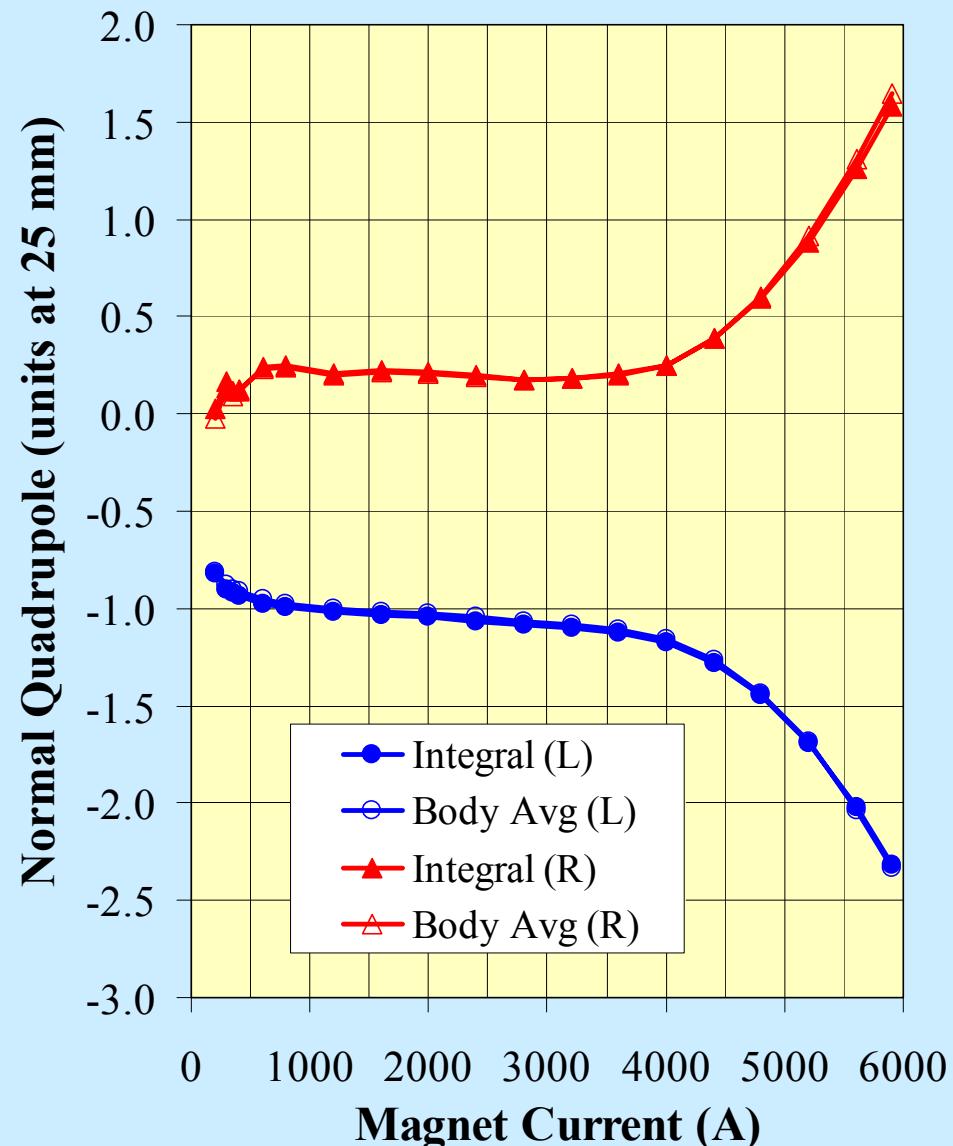
St. Section and Integral T.F. in D3L103



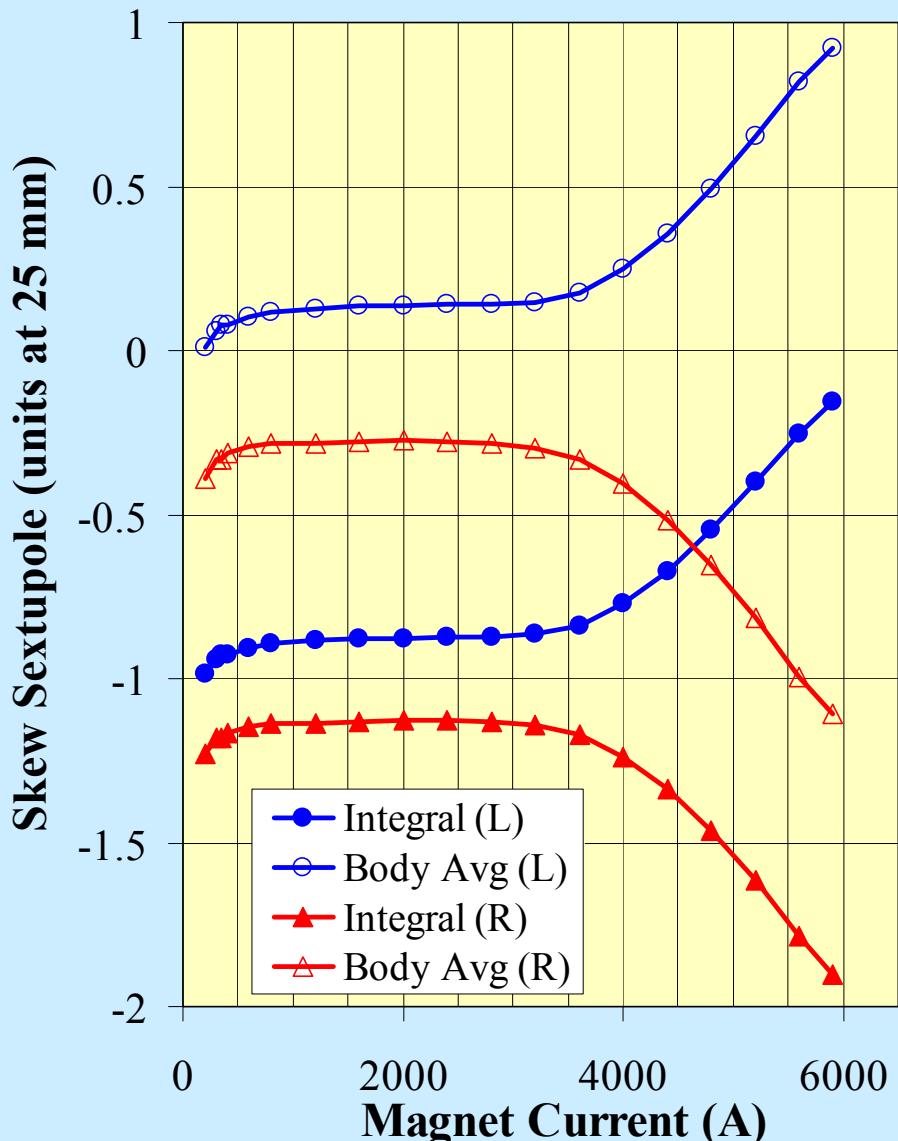
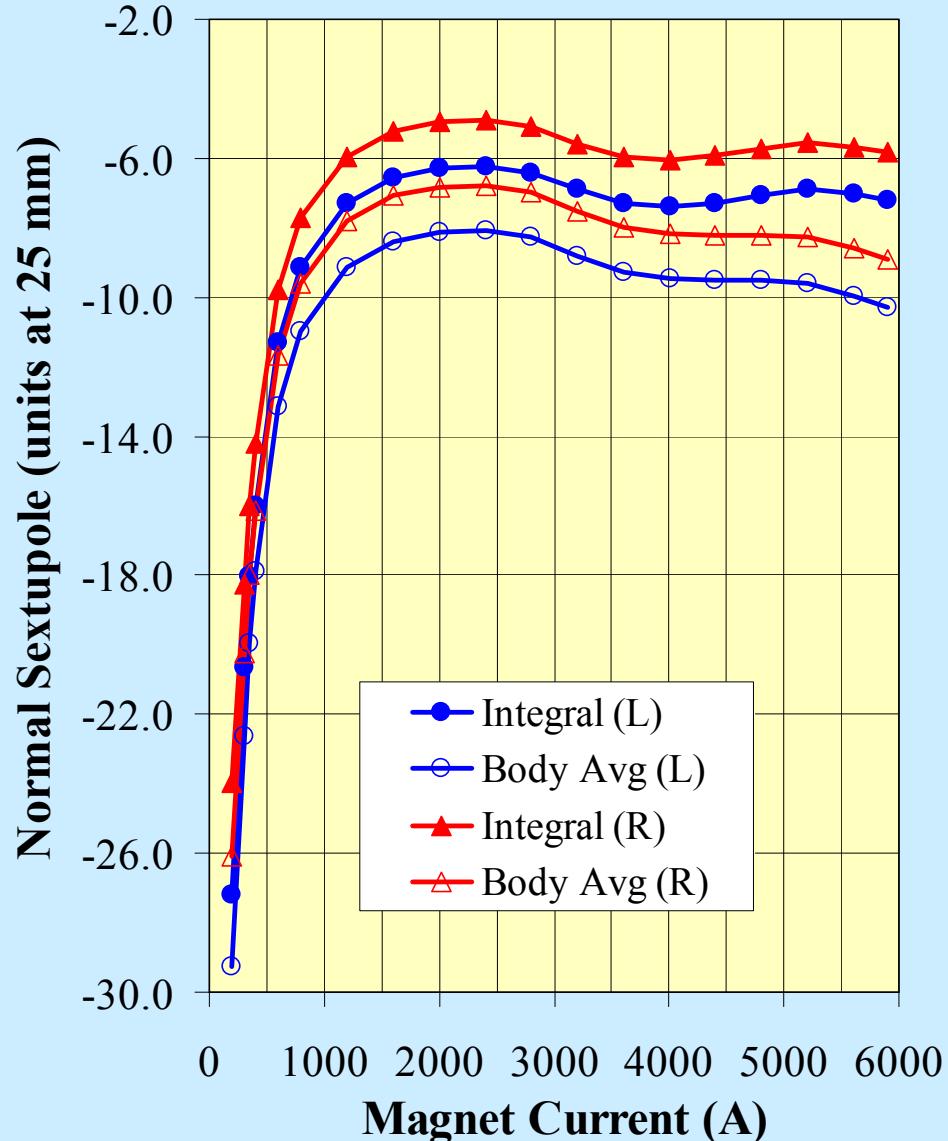
Body TF and ITF W-C Offset differences as a function of Current



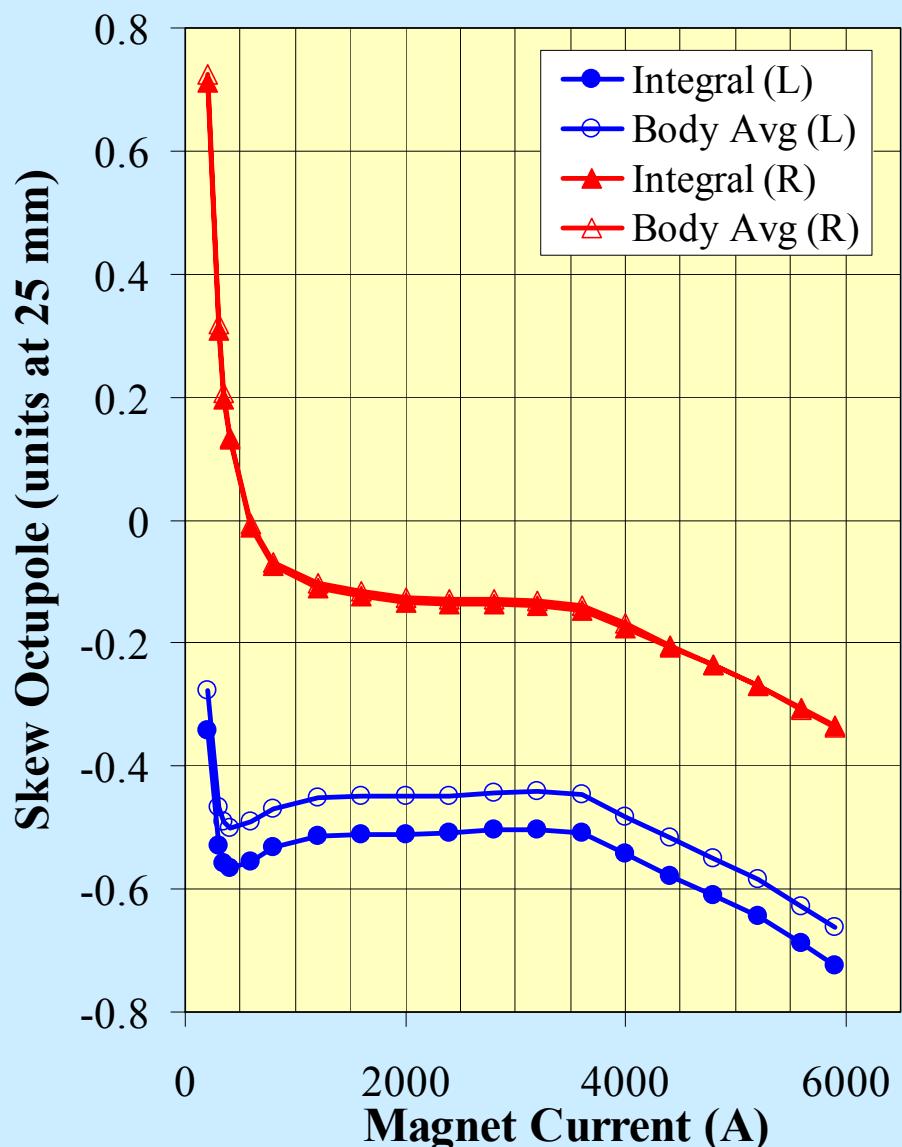
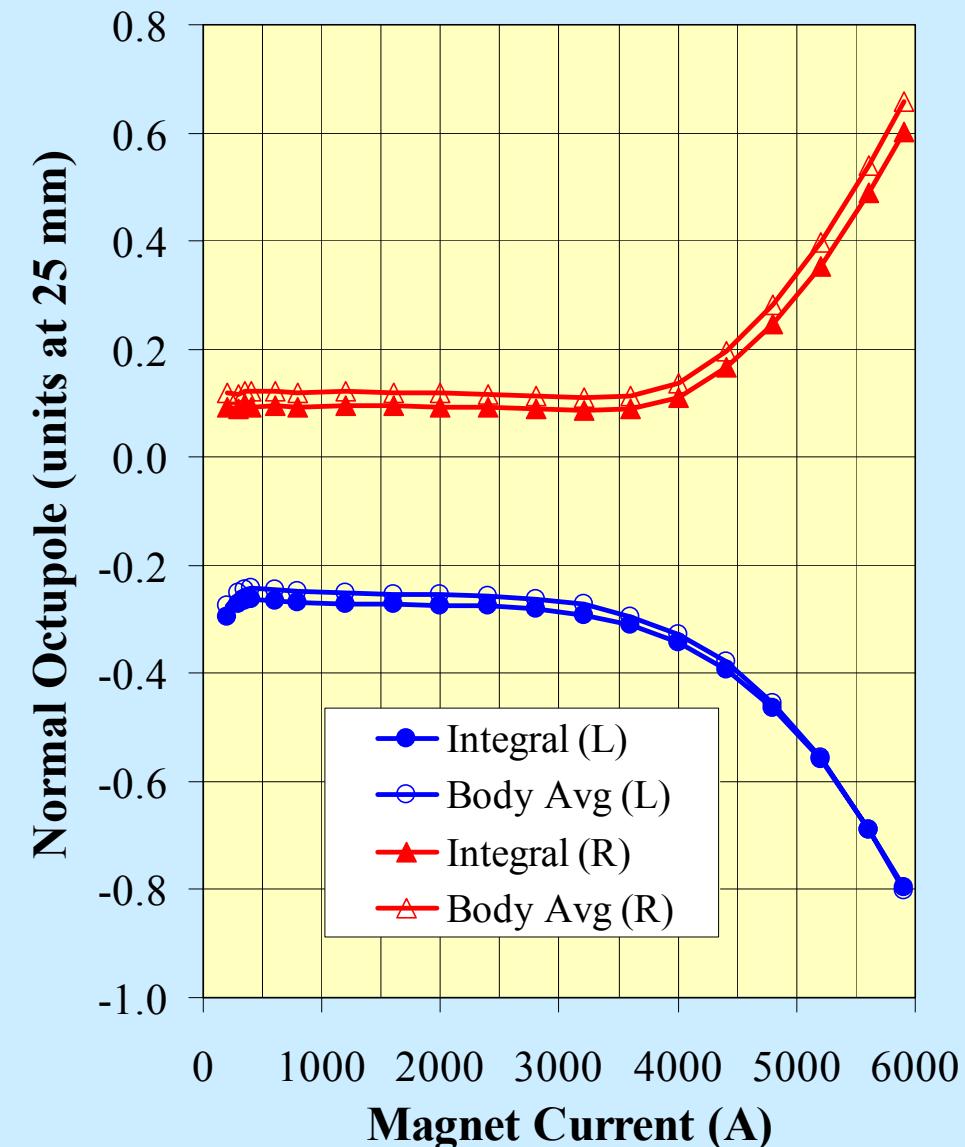
Quadrupole Terms in D3L103



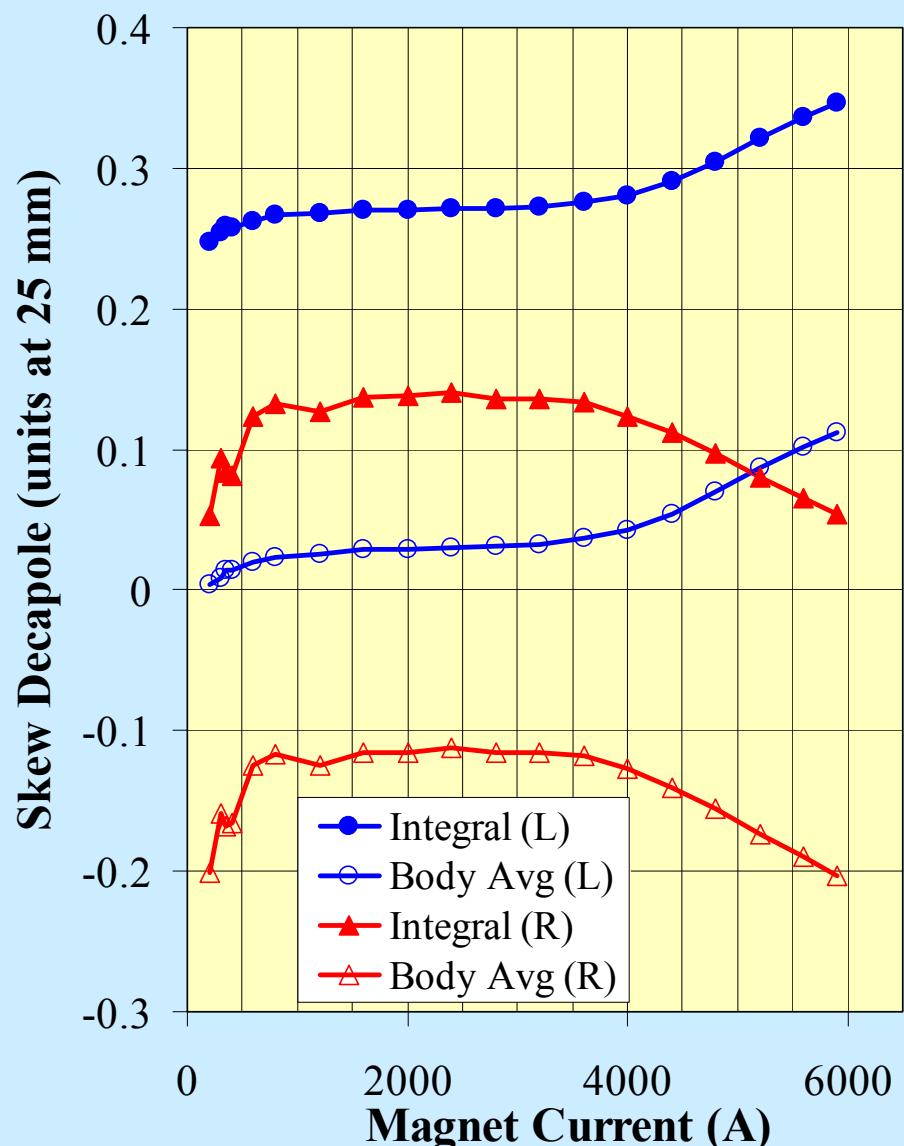
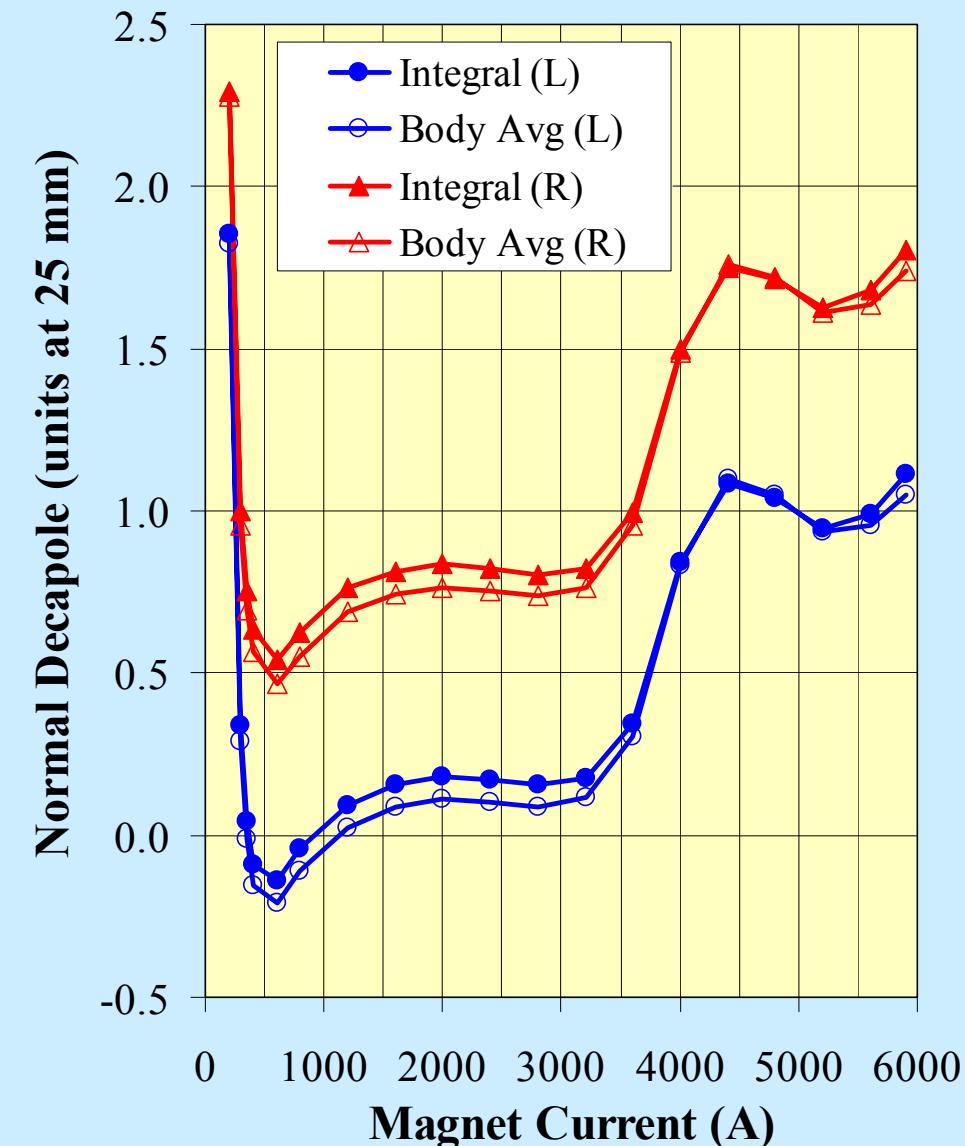
Sextupole Terms in D3L103



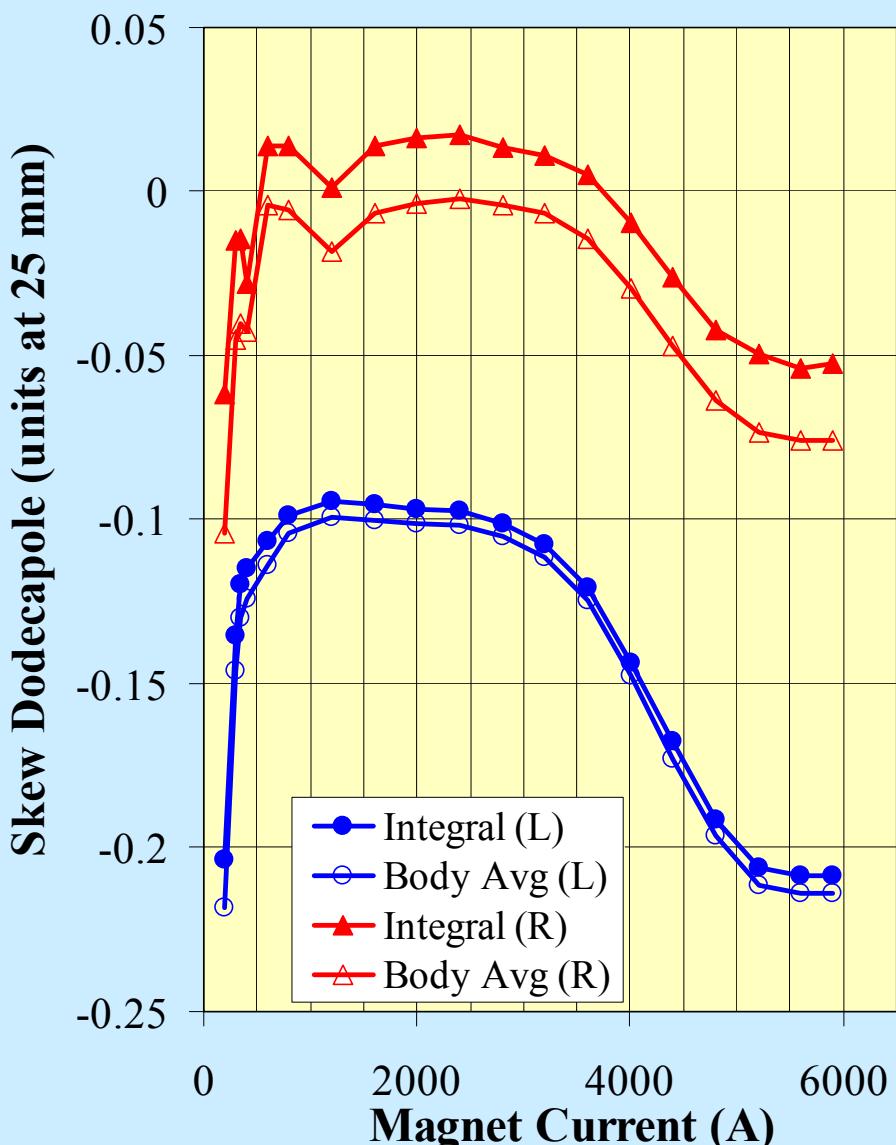
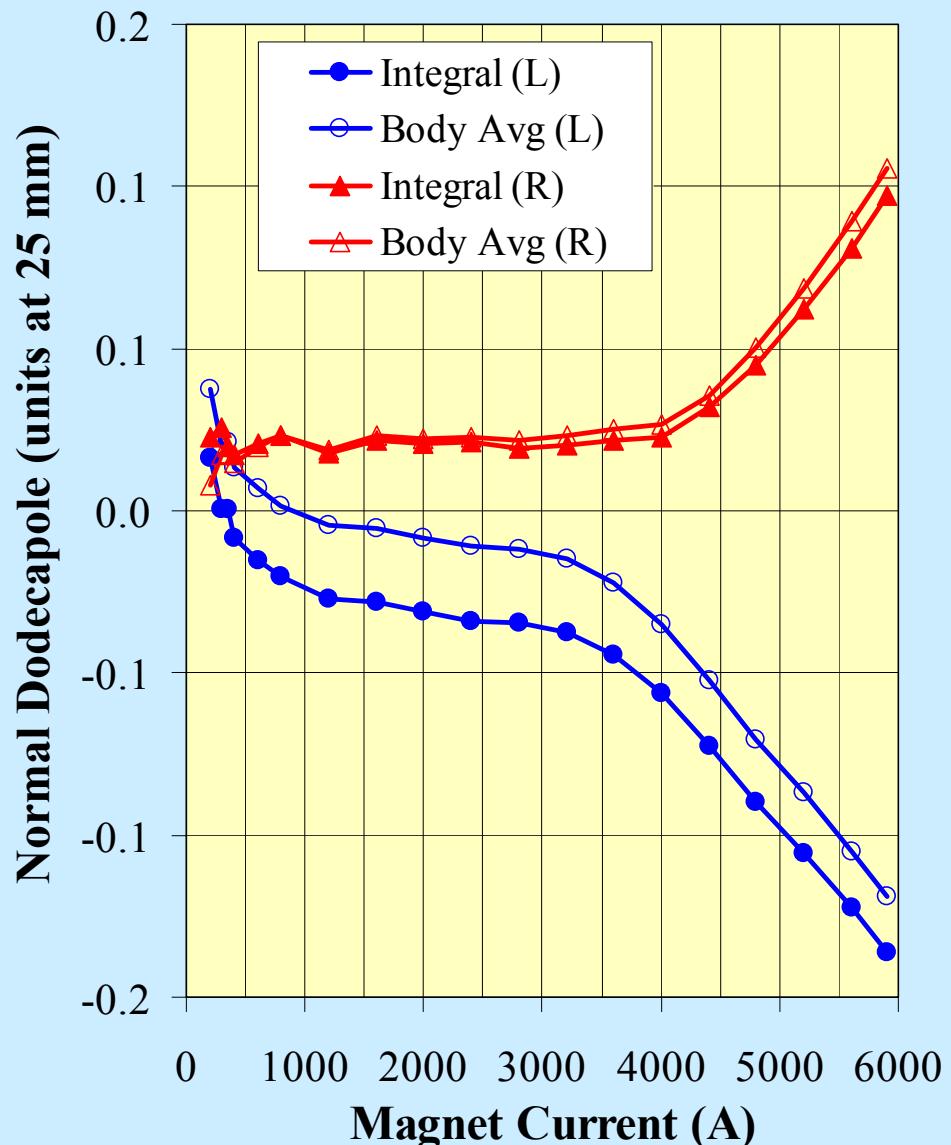
Octupole Terms in D3L103



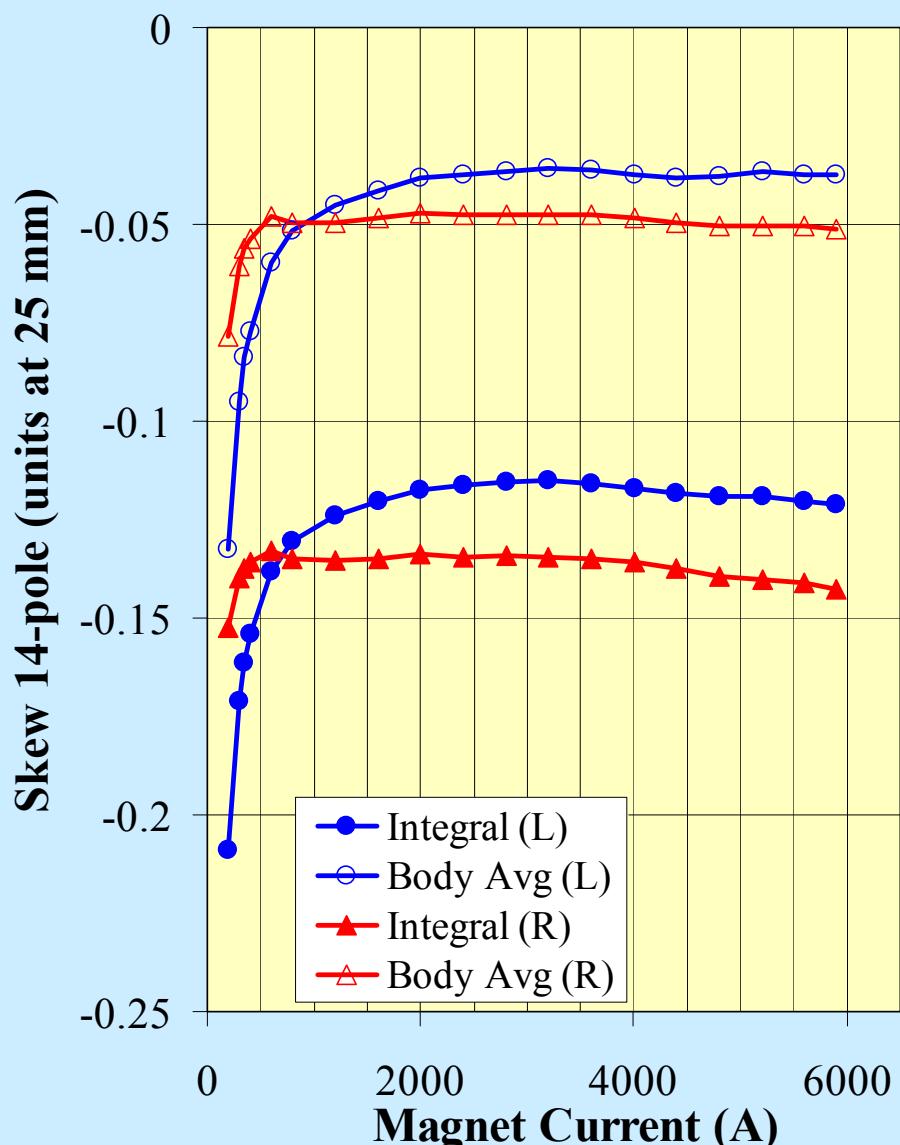
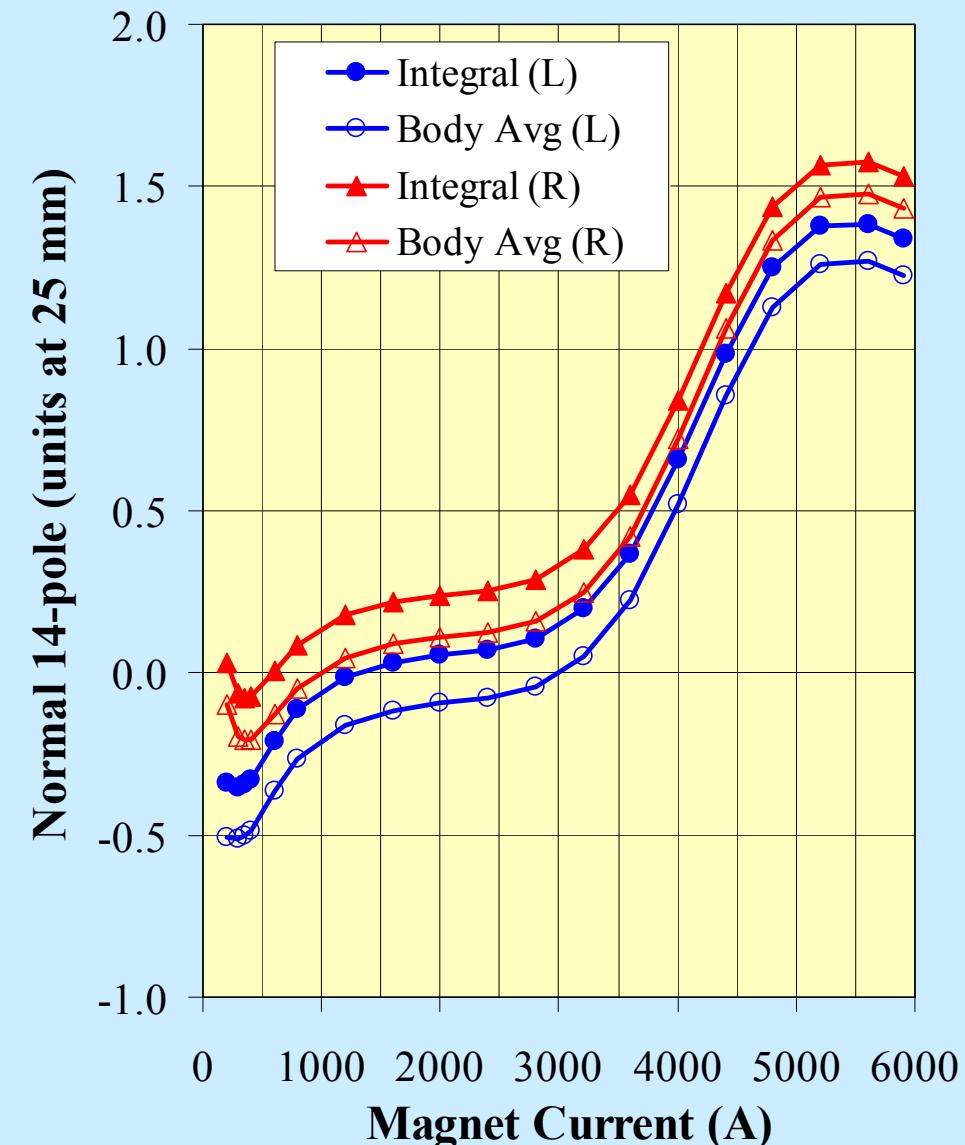
Decapole Terms in D3L103



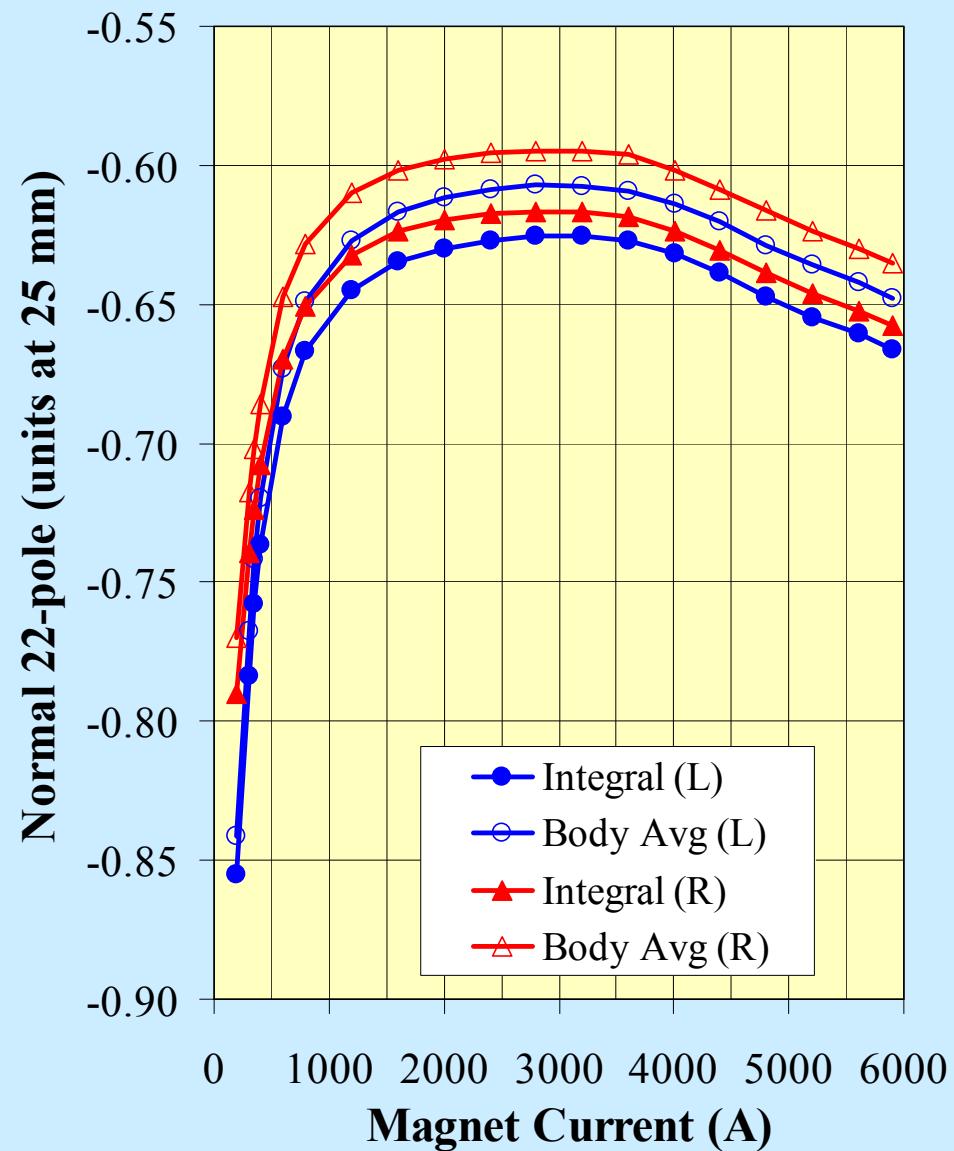
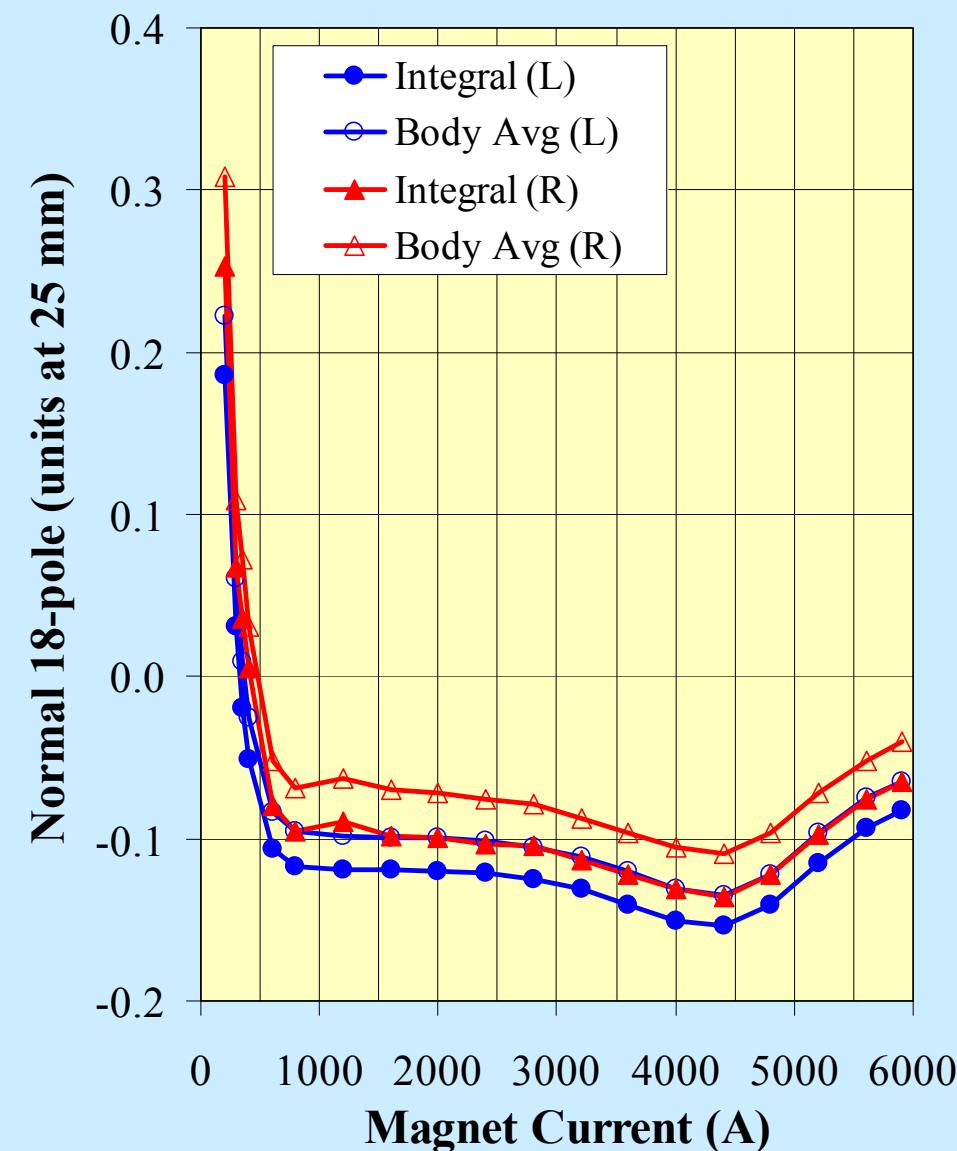
Dodecapole Terms in D3L103



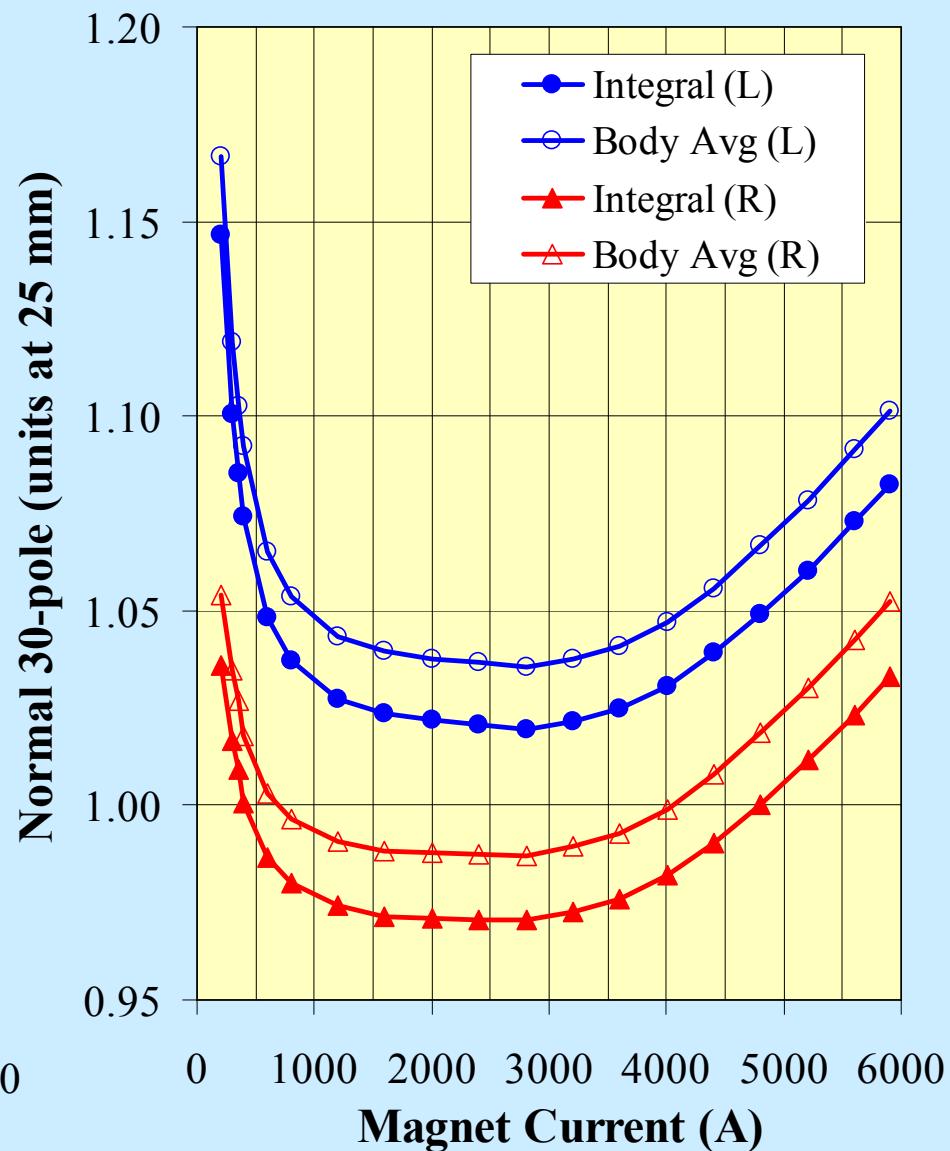
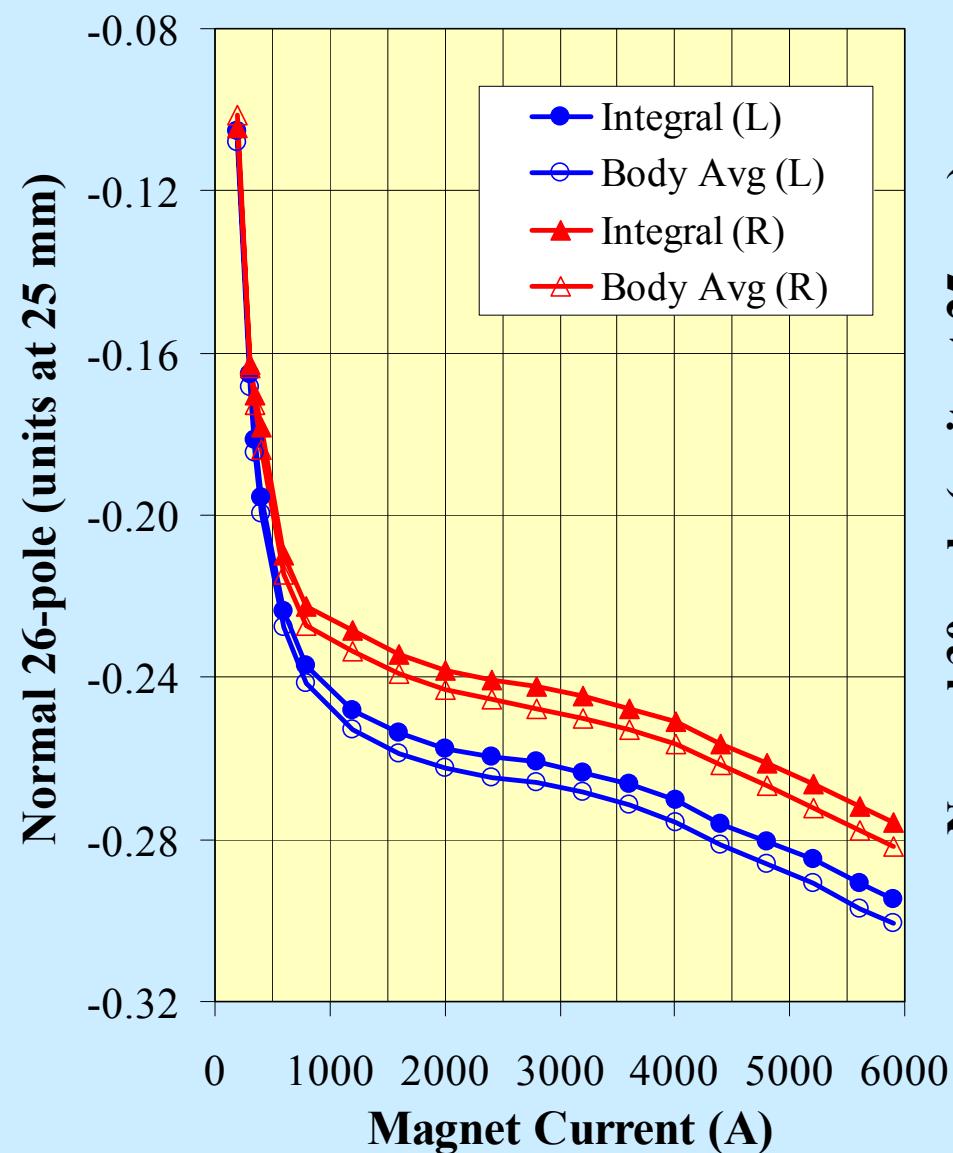
14-pole Terms in D3L103



Normal 18-pole and 22-pole Terms in D3L103



Normal 26-pole and 30-pole Terms in D3L103



Comparison of Field Quality in D3L103 with the Expected Ver 1.0 Tables

Expected Ver 1.0 Table (25 mm)

Integral Harmonics at 300A (0.2 Tesla)

n	$\langle bn \rangle$	$\Delta(bn)$	$\sigma(bn)$	$\langle an \rangle$	$\Delta(an)$	$\sigma(an)$
2	0.11	0.77	0.28	-0.09	3.68	1.53
3	-11.26	5.52	1.95	-1.10	0.49	0.17
4	-0.05	0.20	0.08	0.12	1.15	0.42
5	0.62	0.83	0.40	0.18	0.16	0.06
6	-0.01	0.08	0.03	-0.03	0.54	0.15
7	-0.27	0.21	0.10	-0.09	0.07	0.02
8	-0.03	0.03	0.01	-0.01	0.15	0.05
9	0.14	0.13	0.04	0.02	0.03	0.01
10	0.03	0.05	0.02	0.02	0.05	0.02
11	-0.66	0.04	0.02	-0.01	0.02	0.01

Measured Data in D3L103 & Ver 1.0 Comparison

Integral; 0.2 Tesla (interpolated) at 25 mm radius

n	$bn(L)$	$bn(R)$	$an(L)$	$an(R)$
2	-0.89	0.14	-1.09	-2.06
3	-21.80	-19.24	-0.95	-1.19
4	-0.27	0.09	-0.50	0.38
5	0.60	1.22	0.25	0.09
6	0.00	0.03	-0.15	-0.02
7	-0.35	-0.05	-0.18	-0.14
8	-0.05	-0.01	-0.03	0.07
9	0.06	0.10	0.08	0.02
10	0.01	0.02	0.07	0.09
11	-0.80	-0.75	0.01	-0.01

n	$bn(L)$	$bn(R)$	$an(L)$	$an(R)$
2	OK	OK	OK	OK
3	??	??	OK	OK
4	OK	OK	OK	OK
5	OK	OK	OK	OK
6	OK	OK	OK	OK
7	OK	OK	OK	OK
8	OK	OK	OK	OK
9	OK	OK	??	OK
10	OK	OK	OK	OK
11	??	??	??	OK

Ver.1.0 known issues: Systematic b3 difference from RHIC production; No cross-talk at high field included for D3.

Expected Ver 1.0 Table (25 mm)

Integral Harmonics at 3.8 Tesla (5700 A)

n	$\langle bn \rangle$	$\Delta(bn)$	$\sigma(bn)$	$\langle an \rangle$	$\Delta(an)$	$\sigma(an)$
2	0.25	0.79	0.28	0.54	3.71	1.51
3	-1.71	3.57	1.70	-1.31	0.55	0.18
4	0.07	0.21	0.08	0.06	1.08	0.41
5	0.24	0.80	0.39	0.16	0.17	0.06
6	-0.12	0.10	0.04	-0.05	0.55	0.16
7	1.17	0.19	0.10	-0.11	0.06	0.02
8	-0.02	0.03	0.01	-0.01	0.15	0.05
9	0.01	0.12	0.04	0.01	0.03	0.01
10	0.04	0.05	0.02	0.04	0.04	0.02
11	-0.60	0.04	0.02	-0.01	0.01	0.01

Measured Data in D3L103 & Ver 1.0 Comparison

Integral; 3.8 Tesla (interpolated) at 25 mm radius

n	$bn(L)$	$bn(R)$	$an(L)$	$an(R)$
2	-2.12	1.37	-1.75	-2.30
3	-7.08	-5.73	-0.22	-1.83
4	-0.72	0.53	-0.70	-0.32
5	1.03	1.72	0.34	0.06
6	-0.13	0.09	-0.21	-0.05
7	1.37	1.56	-0.12	-0.14
8	-0.02	0.01	-0.01	0.05
9	-0.09	-0.07	0.03	0.02
10	0.02	0.00	0.08	0.09
11	-0.66	-0.65	-0.01	0.00

n	$bn(L)$	$bn(R)$	$an(L)$	$an(R)$
2	??	??	OK	OK
3	??	OK	??	OK
4	??	??	OK	OK
5	OK	??	OK	OK
6	OK	??	OK	OK
7	OK	??	OK	OK
8	OK	OK	OK	OK
9	OK	OK	OK	OK
10	OK	OK	OK	OK
11	??	OK	OK	OK

OK=Value between ($\text{mean} - \Delta - \sigma$) & ($\text{mean} + \Delta + \sigma$)